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Exploring the relationships between environmental management and financial sustainability in the energy industry: Linear and nonlinear effects

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Abstract

Environmental management plays a pivotal role in the financial performance of the energy industry. A number of studies have focused on the relationship between environmental management and financial sustainability, but the results are inconsistent. In addition, the existing literature failed to study the indirect and nonlinear relationship between the two. To fill this gap, this paper aims to seek out a mediator (debt financing) and employ a threshold effect model to explore the relationship between environmental management and financial sustainability in the energy industry. First, this paper uses least square dummy variable method to examine the relationship among environmental management, debt financing, and financial sustainability, and the results show that environmental management and debt financing have a positive relationship with financial sustainability. Second, the mediating effect model and threshold effect model are employed to examine the relationship among environmental management, debt financing, and financial sustainability, and the results reveal that debt financing can mediate the effect of environmental management on financial sustainability, and there is a nonlinear impact of debt financing on financial sustainability for different thresholds of environmental management. Finally, this paper presents policy proposals to promote the development of the energy industry based on the conclusions.

Keywords

Environmental management, debt financing, financial sustainability, energy industry

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Introduction

Environmental issues are increasingly drawing attention from the international community.[1] However, the phenomena of "high consumption of energy", "high consumption of materials", and "high emissions" are quite common in the operation of the traditional energy industry, and these issues have already aroused the attention of industry and academia.[2,3] The implementation of environmental management (EM) has become one of the most important methods of transforming and upgrading the traditional energy industry to achieve the transition from high consumption of energy and materials and high emissions to green and sustainable operation of the renewable energy industry.[4,5] The sustainability of the energy industry has become an urgent issue as companies try to satisfy market demands and social needs and fulfill future requirements.[6] Sustainability is very important, especially during periods of economic turmoil,[7,8] and it will become more important in the future.[9]

The relationships between economic and environmental sustainability are addressed in the "whether it pays to be green" debate that explores the relationships between EM and financial sustainability (FS).[10,11] The debate is still in flux because the outcomes of the studies addressing the relationships between EM variables and FS variables are not consistent. The presence of conflicting results can be explained by the gaps in the theoretical foundation.

First, an increasing number of studies suggest that the relationship between EM variables and FS variables is not direct; prior research called for an investigation of mediating variables that could convert efforts to reduce environmental impact into benefits for FS.[10] In this study, we examine whether debt financing (DF) mediates the relationship between EM and FS. DF plays a key role in the financing plans and investment decisions of energy companies because it is a concept that accurately reflects the actual financing costs of the financing subject. Exploring the mediating role of DF, we check whether it is positively influenced by the functioning EM and if it in turn contributes to FS. EM includes all the actions that are carried out in a systematized way to monitor the environmental impact of a company's activities and to manage issues related to the environmental dimension.[12]

Second, the variety of findings in the "whether it pays to be green" literature is considered to be a matter of measurement.[11] In particular, different measures and different concepts were applied for both EM and FS variables. Among the environmental variables, both environmental performance and EM were considered. This study follows the methodology of Álvarez Gil et al.[13] and employs EM variables. We chose the EM rather than the environmental performance variable because environmental performance not only results from managerial efforts to reduce environmental impact, but also reflects the type of business activities the company is involved in. Different measures are also suggested in the literature for FS. We follow the method of Sher and Yang[14] and distinguish between two advantages that arise from efforts to reduce environmental impact.

This paper contributes to the literature in the following ways. First, the paper uses the mediation model to verify the transmission mechanism of EM → DF → FS and applies the threshold effect model to test the nonlinear threshold relationship between EM, DF, and FS, which further expands the research field of FS. Second, to control the endogeneity, this paper also applied different methods, including instrumental variables (IVs), the two-stage least squares (TSLS) method, and the system generalized method of moments (system GMM), to make the results more robust and reliable. Finally, the paper provides a managerial contribution as it explores the FS implications of EM and DF. This paper is

organized as follows: the second part presents the literature review and research hypotheses, the third part describes the research methods, the fourth part provides the results, and the last part presents the conclusions and suggestions.

Literature review

Environmental management

By implementing pollution prevention activities, energy companies can reduce their control costs, decrease their consumption of inputs and energy, and increase their reuse of recycled materials.[15] Therefore, the fundamental purpose of eco-efficiency is to produce and deliver goods at lower costs while reducing ecological effects, resource intensity, material intensity, and energy intensity. Then, certain ecological features of products will become a new competitive advantage that is appreciated by "green" customers. In this way, a company can generate a positive reputation associated with environmentally friendly activities.[16] By improving pollution prevention, EM can help companies achieve a win-win situation, which means that both companies and the environment can benefit from the results.[17]

Porter and Vanderlinde[18] proposed the strong and weak hypotheses that if the environmental regulation is strict and appropriate, it will encourage the enterprise's EM behavior (weak hypothesis); it will also guide the enterprise to improve the efficiency of resource utilization and to reduce business costs or increase sales revenue to establish a competitive advantage (strong hypothesis). The Porter hypothesis logically covers both the antecedents and consequences of EM. The antecedent aspect focuses on the analysis of the influence of the factors (especially environmental regulation) on the EM behavior of the enterprise and its driving mechanism. The consequences show that enterprises can improve their environmental and financial performance through EM.

Since the Porter hypothesis was introduced, scholars have conducted many theoretical and empirical studies on it.[19–21] However, due to the differences in research objects and methods, as well as the use of different environmental and financial performance evaluation indicators, scholars have come to inconsistent conclusions when testing the Porter hypothesis. The validation of the Porter hypothesis in the existing literature mainly focuses on three areas: first, to explore the connotation of EM;[19] second, to survey the antecedents of EM behavior, including influencing factors and driving mechanisms;[20] third, to study the consequences of EM behavior, including environmental and financial performance.[21] Studies have also presented other conclusions. For instance, certain aspects of social responsibility affect financial performance, whereas others are not significantly related to financial performance.[22,23] In conclusion, in terms of the impacts of EM on financial performance, a unified conclusion in the academic research field has not been formed.

Debt financing

Since Modigliani and Miller[24] proposed the M-M theorem, the DF of enterprises has been widely concerned by the academic and industry. M-M theorem discusses the impact of DF on corporate value under the perfect market hypothesis, the total corporate value will not be affected by the capital structure under neglecting the influencing of income tax. Then, they modified the M-M theorem in 1963 and concluded that the capital structure of the enterprise affects the total corporate value and the DF will bring the tax saving effect to the company

when considering the impact of income tax.[25] Jensen[26] introduced agency theory into DF of enterprises. He concluded that DF reduces the on-the-job consumption and over-investment behavior of management, alleviates the agency contradiction between shareholders and management so as to the financial sustainability of the company.

A number of studies have focused on the effects of DF on financial performance, especially on profitability. Simerly and Li[27] studied the impacts of financial leverage on corporate performance and found that the impacts might be positive or negative depending on the company's business environment. Abor[28] found that both short-term and total debt positively and significantly affected profitability. Furthermore, Abor[29] found that long-term and total debt ratios negatively affected the financial performance of these enterprises. Weill[30] concluded that financial leverage affected financial performance positively and significantly in Spain and Italy but negatively and significantly in Germany, France, Belgium, Norway, and Portugal.

El-Sayed Ebaid[31] found that short-term debt and total debt had a negative effect on profitability in terms of return on assets (ROA). However, the study did not find any significant relationship between short- or long-term debts and profitability in terms of return on net assets (ROE) or gross profit margins. Salim and Yadav[32] found that long- and short-term debts were negatively related to corporate performance in terms of ROA, ROE, and earnings per share. Onchong'a et al.[33] examined the effects of DF on the financial performance of companies in the short term and long term and found that the debt ratio was inversely related to ROA. Cole and Sokolyk[34] studied the relationship between various patterns of DF at the firm's start-up and the subsequent outcomes and concluded that companies using debt at start-up enjoyed a higher possibility of survival and better revenues than companies using only equity at start-up.

All of these empirical studies indicate that no universal conclusion has been established. These studies used different methods and models to examine financial performance and presented diverse results. Considering the different social and economic backgrounds of these studies, the institutional framework may affect the relationship between DF and financial performance, which may explain the diverse results of these studies. Therefore, this relationship should be examined in the context of China's energy industry.

Financial sustainability

To explore the internal relationship between the growth rate of enterprise value and financial resources, Higgins[35] provided the theory of financial sustainable growth and defined the concept of the financial sustainable growth rate. He believed that the financial sustainable growth rate of an enterprise is the maximum sale rate that can be achieved without running out of financial resources. Based on the definition of Higgins,[35] Horne[36] defined the financial sustainable growth rate as the maximum annual growth rate of sales that can be achieved under a certain ration between operating and debt.

Considerable attention has been focused on FS in recent decades, which was confirmed in the literature review by Kleindorfer et al.[37] Linton et al.[38] described the growing quantity of FS research results in academic and practitioner journals. De Brito et al.[39] explored how FS affected the fashion retail supply chain in Europe. Bai and Sarkis[40] focused on FS in the choice of suppliers and designed a model to assess it. Chaabane et al.[41] applied quantitative techniques to the design of sustainable supply chains.

FS is usually calculated through economic, environmental, and social longevity and foresight, which have been referred to as the triple bottom line.[6,42] Due to voluntary and compulsory environmental standards, EM activities tend to be more popular, especially in manufacturing supply chains. For instance, Vachon and Hajmohammad[43] studied the impacts of EM on performance in the service field. Valero-Gil et al.[44] examined EM by exploring the effects of operations proactivity on the execution of EM systems. Additionally, Chakraborty and Verma[45] focused on the unique concern regarding benchmarking the greening of businesses.

Proposed hypotheses

Scholars have found that corporate social reputation affects corporate value, potential earnings, and corporate FS. Wang and Berens[46] demonstrated that the relationship between corporate social reputation and financial performance is stronger than the direct impact from social responsibility. Li and Wu[47] found that an increase in environmental investments has led to a decrease in both corporate revenues and costs, but the decrease in costs was more significant. As a result, corporate profits increased. Zhu and Zhang[48] concluded that there is an interaction between corporate social responsibility and financial performance in China and that a significant positive correlation occurs between the two. In summary, this paper proposes the first hypothesis as follows:

H1: *EM can effectively promote corporate FS.*

Wang[49] examined the relationship between DF, corporate governance, and the market value of all listed companies in the Shenzhen Stock Exchange and the Shanghai Stock Exchange. That study found that DF in general strengthens corporate governance and increases the market value of the company, and DF serves as a signal that reflects corporate performance. EM can improve a company's social reputation and financial performance. Therefore, a company should increase its investments in the environment to achieve long-term sustainable development. Then, this paper proposes the second hypothesis:

H2: *DF can promote corporate FS.*

Neville et al.[50] used corporate social reputation as a mediator to examine the relationship between corporate social responsibility and financial performance. Galbreath[51] examined three potential benefits of demonstrating corporate social responsibility: reduced employee turnover, increased customer satisfaction, and improved reputation. The results suggest that corporate social responsibility activities provide visible signals from which stakeholders infer various positive characteristics of firms, thus improving firm reputation. Veh et al.[52] provided a systematic review of the literature based on a large-scale bibliometric analysis. They recommended focusing on corporate reputation as an attitudinal concept and thereby emphasizing the stakeholder who acts as an evaluator of the corporation. As one of the most important corporate social responsibilities, EM can effectively improve the reputation and DF ability of companies.[53] Therefore, this paper proposes the third hypothesis and its flow chart is shown in Figure 1:

H3: *EM promotes corporate FS through DF.*

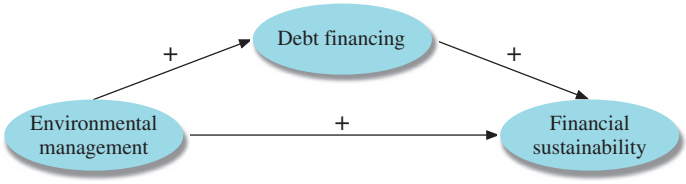

Figure 1. The flow chart of hypothesis.

Data and methodology

Data source

This paper selected the annual reports and environmental reports of energy companies publicly disclosed by the Chinese A-share market listed from 2008 to 2017 as the data samples. These data were collected from the China Stock Market & Accounting Research (CSMAR) and Reset databases. Since most traditional energy companies pay serious attention to the issue of EM, the paper refers to select thermal power plants as observation examples from traditional energy companies. The thermal power plant is the consumption of resource-oriented enterprise. It must consume a lot of fossil energy and other resources in the production process. Meanwhile, it also discharges harmful substance and destroys the natural environment.[54] Analyzing the financial status of thermal power plant enterprises will, on the one hand, conducive to improving the ability of sustainable development from a new perspective, and on the other hand, conducive to energy conservation, emission reduction and environment protection.[55] The questionnaire surveys for EM were collected from 215 subsidiary thermal power plants of the listed energy companies.

Variables

Financial sustainability. The existing literature studies FS from different perspectives, and there is no unified conclusion because of the use of different measurement methods. Each measurement method has its own advantages and disadvantages. Considering the data characteristics of this paper and the comprehensiveness of the evaluation indicators, we use the factor analysis method to measure FS. We follow Sher and Yang,[14] and this paper divided FS into two dimensions: short-term profitability and long-term development capacity.

Short-term profitability (STP). Profitability refers to the ability of a company to make a profit. The fundamental goal of a company's survival is to obtain profits. The acquisition of profits is the guarantee of the realization of investors' interests and the basis for the sustainable growth of companies.[35] If the company has a lower profitability and even suffers from continuous losses, the survival of the company will be threatened. High-quality profitability is the basis for the company to maintain its sustainable growth. In this paper, the measurement of profitability is mainly based on financial performance indicators, that is, ROA, ROE, and operating profit margin (OPM).

Long-term development capacity (LTD). The existing literature posited that managers are concerned about the improvement of business performance,[56–58] while investors are more interested in long-term profit.[59] Therefore, this paper selects three indicators, net profit

Table 1. Total variance explained.

	Rotation sums of squared loadings		
Component	Total	% of variance	Cumulative %
1	3.085	55.341	55.341
2	2.958	35.293	90.634

Table 2. Rotated component matrix.

	Component	
Factors	1	2
ROA	0.884	0.051
ROE	0.871	0.059
OPM	0.885	−0.018
EPS	0.032	0.953
NPGR	0.013	0.925
TAGR	0.006	0.907

growth rate (NPGR), earnings per share growth rate (EPS), and total asset growth rate (TAGR) as the measurement indicators of the company's long-term development capacity.

We first performed Kaiser–Meyer–Olkin (KMO) and Bartlett's tests on the sample data. The results show that the KMO value is 0.698, which is greater than 0.5, indicating that the factor analysis method is appropriate. The Bartlett's test has a $p < 0.001$, which also indicates that the sample data are valid for factor analysis. Second, we extracted the common factor and performed a dimension reduction of the principal component. The results are shown in Table 1. The cumulative contribution rate of the two principal component factors reached 90.634%, indicating that the indicator system retains most of the information from the original variables. Finally, we established a load matrix for the two principal components factors. The results are shown in Table 2. Then, we built the following comprehensive indicators: STP and LTD

$$\begin{aligned} F_1 &= 0.884ROA + 0.871ROE + 0.885OPM + 0.032EPS + 0.013NPGR + 0.006TAGR \\ F_2 &= 0.051ROA + 0.059ROE - 0.018OPM + 0.953EPS + 0.925NPGR + 0.907TAGR \\ FS &= (55.341F_1 + 35.293F_2)/90.634 \end{aligned} \quad (1)$$

where F_1 and F_2 are the common factors extracted by principal components analysis.

Environmental management. This paper adopted the measurement scales for EM practices proposed by Álvarez Gil et al.[13] To obtain an overall indicator from different aspects of EM, we designed seven items to explore EM of energy companies: quantification of environmental costs and savings, environmental training programs, deployment of green purchasing policies, use of green arguments in marketing campaigns, demands for customer cooperation in environmental protection programs, adoption of energy- and water-saving actions, and service collection of paper, oil, glass, and other materials.[13] The environmental

legislation that regulates the energy industry suggested that most activities should fall into the category of "pollution prevention", although some items focused on "pollution control". Managers from energy companies were invited to score the seven items on a scale of 0–10. The results reflect the degree of involvement in each activity.

Similar to the calculation of FS variable, this paper calculated the EM variable through combing the seven items into one group as a single factor in Table 3. The Cronbach's alpha value (0.86) is higher than the limit of 0.70 established by Nunnally[60] to guarantee internal consistency. In addition, the convergent validity of this factor has been ensured by the employment of a complementary measurement. This paper followed the approach of other studies by adopting the creation of an environmental plan as a proxy for EM in energy companies.

Debt financing. We use the DF proxy, denoted *Leverage*, which is equal to the ratio of long-term debt to total assets, each measured at book value.[61] The employment of "long-term book leverage" can help to reduce the possibility of reverse causality between performance and capital structure in at least two ways. First, differing from market values, long-term book values are insensitive to capital markets' assessments about performance in the near future. Second, although leverage changes (e.g. leveraged buyouts) may reflect changes in expectations about ensuing product outcomes, leverage levels reflect the cumulative effect of previous financing decisions. In this paper, the samples' debt-to-asset distribution was set in the [0, 1] range. This means that the firm-years with negative book equity (nearly bankrupt firms) were removed from the sample.

Control variables. After referring to the existing literature, three control variables were included in our study.[13,58] We select the size of company (*Size*), growth rate of the total output value of the energy industry (*GTOV*), and net assets per share (*Ass*). For alternative variables, *Size* uses the natural logarithm of total assets, *Ass* uses the ratio of stockholder equity to total stock, which reflects the company's profitability.

Table 3. Factor analysis results of EM items subjective scales.

	Factor loading		
Scale and item	1	2	3
The company quantifies in its budget its environmental savings and costs	0.22	**0.68**	0.19
The company gives the employees training on environmental issues	0.35	**0.66**	0.12
The company gives priority to purchasing ecological products (biodegradable, reusable, recyclable, etc.)	0.11	**0.74**	0.25
The company uses ecological arguments in its marketing campaigns	0.07	**0.76**	0.34
The company facilitates customer collaboration in environmental protection (voluntary changing of towels, etc.)	0.14	**0.68**	0.35
The company applies energy and water saving practices	0.13	**0.66**	0.31
The company makes a selective collection of paper, oil, glass, etc.	0.17	**0.68**	0.14
Eigenvalue		3.71	
Total percentage of variance explained (%)		77.95	
Alpha		0.86	

This scale is referenced from Álvarez Gil et al.[13]

Modeling

The model of EM, DF, and FS is established as follows

$$FS_{it} = a_0 + a_1 Em_{it} + a_2 DF_{it} + a_3 Em_{it} * DF_{it} + \beta X_{it} + \varepsilon_{it} \quad (2)$$

where i and t represent the company and the year, respectively. FS_{it} represents FS, Em_{it} represents EM and DF_{it} represents DF. $Em_{it} * DF_{it}$ represents the interaction term for EM and DF, X_{it} represents control variables and ε_{it} represents random errors. The definition of all variables is displayed in Table 4. In processing the data, data points falling within the 2% tail of the distribution were removed for all continuous variables to minimize the impact of outliers on the estimation results. The statistical results of the description of variables are shown in Table 5.

Methods

Least square dummy variable (LSDV) estimation. The LSDV method first estimates the dynamic panel model, and the estimation coefficient is denoted as $\widehat{\beta_L}$. Second, we estimate the bias of the LSDV, denoted as $\widehat{Bias}$. Finally, the uniform estimation of deviation correction can be obtained from the difference between $\widehat{\beta_L}$ and $\widehat{Bias}$ as follows

$$\widehat{\beta} = \widehat{\beta_L} - \widehat{Bias} \quad (3)$$

Table 4. The definition of variables.

Variables	Symbols	Definition
Debt financing	*DF*	Long-term debt to total assets
Size	*Size*	Ln (total assets)
Growth rate of the total output value of industry	*GTOV*	$(TOV_2\text{-}TOV_1)/TOV_1$
Net assets value per share	*Ass*	The ratio of stockholders equity to total stock
Environmental management	*Em*	Calculated by factor analysis
Financial sustainability	*FS*	Equation (1)

Table 5. The description analysis.

Variables	Mean	St. Dev.	Max.	Min.	Jarque–Bera
FS	0.54	3.35	2.57	−0.73	0.38
EM	5.51	2.35	7.02	3.95	0.41
DF	0.23	0.24	0.35	0.12	0.29
Size	21.32	1.52	23.89	19.51	0.26
GTOV	0.137	0.852	0.26	0.04	0.33
Ass	2.89	1.48	6.21	−0.55	0.38

The Jarque–Bera test is presented as *p*-value.

where the standard error of $\widehat{\beta}$ can be obtained by the bootstrap method. However, this method requires all the explanatory variables to be strictly exogenous, and it cannot solve the potential endogeneity problem in the model. This problem can be solved by the system GMM method through introducing IVs.

Two-stage least squares (TSLS). The IV method usually uses the TSLS method to perform the regression analysis, which is divided into two stages. In the first stage, each explanatory variable that is an endogenous covariate in the equation of interest is regressed on all of the exogenous variables in the model, and the predicted values from these regressions are obtained. In the second stage, the regression of interest is estimated as usual, except that in this stage, each endogenous covariate is replaced with the predicted values from the first stage.

System generalized method of moments (system GMM), Arellano–Bond AR, and Sargan test. Blundell and Bond[62] derived a condition under which it is possible to use an additional set of moment conditions. These additional moment conditions can be used to improve the small sample performance of the Arellano–Bond estimator. Specifically, they advocated using the moment conditions

$$E\left(\triangle y_{it-1}(\alpha_i + u_{it})\right) = 0, \quad t \geq 3 \tag{4}$$

These additional moment conditions are valid under the conditions provided in their paper. In this case, the full set of moment conditions can be written as follows

$$E\left(Z_{sys,i}^{T}, P_i\right) = 0 \tag{5}$$

where

$$P_i = \begin{bmatrix} \triangle u_i \\ u_{i3} \\ u_{i4} \\ \vdots \end{bmatrix} \quad \text{and} \quad Z_{sys,i} = \begin{bmatrix} Z_{di} & 0 & 0 & 0 \\ 0 & \triangle y_{i2} & 0 & 0 \\ 0 & 0 & \triangle y_{i3} & 0 \\ 0 & 0 & 0 & \ddots \end{bmatrix} \tag{6}$$

Arellano and Bond[63,64] identify how many lags of the dependent variable, the predetermined variables, and the endogenous variables are valid instruments and how to combine these lagged levels with first differences of the strictly exogenous variables into a potentially large instrument matrix. They derive the test of autocorrelation of order m and the Sargan test of overidentifying restrictions; The Arellano–Bond estimator is designed for datasets with many panels and few periods, and it requires that there be no autocorrelation in the idiosyncratic errors. For a related estimator that uses additional moment conditions, but still requires no autocorrelation in the idiosyncratic errors.

Threshold model analysis. Threshold models are often used to model the behavior of groups, ranging from social insects to human society. Classic threshold models were developed by Schelling[65] to model collective behavior. Following Schelling,[65] Granovetter and Soong[66]

proposed the threshold model, which assumes that individuals' behavior depends on the number of other individuals already engaging in that behavior. Granovetter relates "threshold" to the utility one gets from participating in collective behavior or not; using the utility function, each individual will calculate his or her cost and benefit from undertaking an action.

Results

Baseline regression analysis

To avoid the error of model setting and improve the effectiveness of parameter estimation, Hausman test is used to distinguish the form of the panel data model. The null hypothesis of the Hausman test is the random effect model. If the null hypothesis is accepted, the random effect model should be applied. If the null hypothesis is rejected, the fixed effect model should be applied. In this paper, the Hausman test has a *p*-value of 0.001, which rejects the null hypothesis. Therefore, the fixed effect model is applied and shown in the note of Table 6.

We first conduct the LSDV estimation on the relationship of EM, DF, and FS. The results are shown in Table 6. This table shows that the F statistics are large and that all pass the 1% significance level test, indicating that the overall coefficient of the model is significant and that the conclusion is reliable. Model 1 includes the equation (2) estimates without the interaction terms and control variables, and Model 2 includes the equation (2) estimates without the interaction terms. The regression coefficients of EM are significantly positive, and all pass the 5% significance level, indicating that the EM of energy companies has significantly improved the FS. Thus, Hypothesis 1 has been verified. From the estimation

Table 6. The results of baseline regression.

Variables	Model 1	Model 2	Model 3
Cons.	8.75	12.34	6.89*
	(6.73)	(9.47)	(4.37)
EM	1.92**	1.73**	
	(3.21)	(2.35)	
DF	2.55***	2.97***	2.686***
	(5.38)	(7.75)	(7.34)
*EM*DF*			3.55***
			(5.84)
Size		0.82**	1.25**
		(1.68)	(2.37)
GTOV		1.95*	1.54*
		(3.79)	(2.38)
Ass		2.77*	3.38*
		(5.65)	(6.21)
AdjustedR^2	0.525	0.521	0.558
F-value	22.93***	21.66***	20.43***

***, **, * denotes significance at 1%, 5%, and 10% levels, respectively; ( ) represents *Z*-value. The results are estimated by the fixed effect model.

results of DF, the regression coefficient is significantly positive in all models, and both pass the 1% significance level test, indicating that DF has significantly promoted FS. Thus, Hypothesis 2 has been verified.

Model 3 includes the equation (2) estimates with the interaction terms and is used to explore whether EM will exacerbate the impact of DF on FS. From the regression result of Model 3, the coefficient of DF on FS is still significantly positive, which verifies Hypothesis 2 again. The result of the interaction term test shows that EM can promote the positive impact of DF on FS. Thus, Hypothesis 3 is verified.

From the estimation results of control variables, the coefficient of *Size* is 1.25, and it is significant at the level of 5%, which indicates that larger energy companies present an increased ability to achieve sustainable development. The coefficient of *GTOV* is 1.54, and it is significant at the level of 10%, thus indicating that the growth rate of the total output value of the energy industry is positively related to FS. The coefficient of *Ass* is 3.38, and it is significant at the level 10%, thus indicating that the stronger the company's profitability is, the higher the FS.

Endogeneity test

We consider that the explanatory variables (EM and DF) may be endogenous. Although LSDV estimates can control the endogeneity problem caused by missing some variables, it is difficult to avoid the endogeneity problem caused by the bilateral causal relationship between variables. Therefore, this paper uses the IV method to control the endogeneity problem. Specifically, to solve the endogeneity problem, this paper first performed the dispersion transformation on the fixed effect model and then estimated the transformed model by the TSLS method. The TSLS estimate requires that the endogenous explanatory variables must be specified in advance and should be defined by appropriate IVs. In this paper, EM and DF were regarded as endogenous explanatory variables, and their lagging variables were used as IVs. The estimation results of panel IVs are shown in Table 7.

Model 1 in Table 7 is the IV estimation result of equation (2) without the interaction term, and Model 2 is the IV estimation result of equation (2) with the interaction term. As shown in Table 7, the *Anderson canon corr. LM* statistic used for "unrecognizable tests" in all models rejects the null hypothesis at the 1% level, indicating that the IV set is identifiable. At the same time, the Cragg–Donald Wald F statistic used in the "weak instrumental variable test" in all models is significantly larger than the critical value (8.03) at the 10% bias level, rejecting the null hypothesis. In summary, it can be determined that the IV sets are effective and reasonable. In addition, since the number of IVs selected is exactly equal to the number of endogenous explanatory variables, there is no overidentification problem. The coefficient symbols of the explanatory variables examined are basically consistent with the estimation results in Table 6, indicating that there is no endogeneity in the statistics, which means that the model estimation using the LSDV method is reliable. In addition, the direction, magnitude, and significance level of the coefficients of each control variable in this model are also consistent with the results of the baseline regression analysis.

Robustness test

FS is a continuous dynamic process in which the early financial situation has a dynamic impact on current and future financial conditions. However, the model designed in this

Table 7. The results of 2SLS estimation.

Variables	Model 1	Model 2
Cons.	10.52	11.41**
	(8.41)	(8.98)
EM	1.96**	
	(3.77)	
DF	1.09***	3.077***
	(5.25)	(9.16)
*EM*DF*		2.43***
		(4.71)
Size	1.37*	1.32**
	(3.11)	(3.13)
GTOV	1.25**	2.31**
	(3.05)	(4.02)
Ass	2.15**	1.32**
	(10.21)	(4.14)
Uncentered R^2	0.323	0.345
Anderson canon. corr. LM value	98.31***	97.32***
Cragg–Donald Wald F value	82.49	80.19

***, **, * denotes significance at 1%, 5%, and 10% levels, respectively; ( ) represents *Z*-value.

paper does not take the dynamic subsequent effect into consideration, so the above research results may not be robust and reliable. Therefore, this paper considers the method of replacing the variables, adding the lag term of FS to the model, and using the system GMM to conduct robustness estimations for Hypotheses 1, 2, and 3. As seen in Table 8, there is no second-order correlation (p-values are all significantly greater than 0.1) for the residuals of all model differences. The Sargan test results show that the overrecognition constraints in the model are valid (p-values are close to 1), indicating that the selected IVs are effective. The coefficient symbols of variables are basically consistent with the results of the baseline regression analysis, and the significance is improved. The above robustness test results also verify Hypotheses 1, 2, and 3 in this paper.

Retesting the interaction effect: Mediating effect model

The regression model above used the "interaction term test" to initially explore the transmission mechanism of EM through DF affecting FS. However, the coefficient of the interaction term of EM and DF was significantly positive, which was most likely caused by the interaction between the environmental behaviors of China's energy industry and the capital allocation behaviors of the capital market. It is this interaction that has an impact on the corporate FS. In other words, the "interaction item test" may not be able to effectively identify the promotion effect of EM on FS through DF described in Hypothesis 3, which reveals the transmission mechanism of EM → DF → FS. Therefore, this paper uses the mediating effect test proposed by Baron and Kenny[67] to construct the following recursive model to accurately identify the transmission mechanism of EM → DF → FS

$$FS_{it} = \beta_0 + \beta_1 EM_{it} + \eta X_{it} + \varepsilon_{it} \quad (7)$$

Table 8. The system GMM results.

Variables	Model 1	Model 2
Cons.	12.31*	13.05***
	(8.94)	(8.41)
EM	3.21**	
	(5.01)	
DF	1.73***	5.134***
	(6.04)	(10.07)
*EM*DF*		3.01***
		(4.95)
FS_{t-1}	5.33**	4.72***
	(11.52)	(8.77)
Size	1.52**	1.91**
	(3.84)	(3.59)
GTOV	1.47**	3.08**
	(3.51)	(4.79)
Ass	1.04**	1.63**
	(8.08)	(8.85)
Arellano–Bond test AR (2)	0.287	0.311
Sargan test	0.987	0.994

***, **, * denotes significance at 1%, 5%, and 10% levels, respectively; ( ) represents *Z*-value. The AR and Sargan test are presented as *p*-value.

$$DF_{it} = \lambda_0 + \lambda_1 EM_{it} + \theta X_{it} + \varepsilon_{it} \tag{8}$$

$$FS_{it} = \alpha_0 + \alpha_1 EM_{it} + \alpha_2 DF_{it} + \varphi X_{it} + \varepsilon_{it} \tag{9}$$

The first step is to perform a regression of equation (7) and test whether the coefficient β_1 of the EM is significant. If β_1 is significant, it means that the EM behaviors of energy companies have an impact on FS. The second step is to perform a regression of equation (8) to test the effect of EM on DF (mediator). If the regression coefficient λ_1 is significant, EM will affect DF. The third step is to perform a regression on equation (9). If the coefficients α_1 and α_2 of EM and DF are significant and the coefficient α_1 decreases compared with the absolute value of the coefficient β_1, there is a partial mediating effect. If the coefficient α_2 is significant and the coefficient α_1 is not significant, it may mean that DF plays a fully intermediary role.

Table 9 is the estimation result of the mediating effect test. The estimation result of Model 1 shows that the EM coefficient β_1 is significantly positive and passes the 1% significance level test. The estimation results of Model 2 show that the EM coefficient λ_1 is significantly positive at the 1% level. From the estimation result of Model 3, it can be seen that the EM coefficient is significantly positive at the 5% statistical level, and the coefficient of DF is positive and passes the 1% significance level test. In addition, it can be found that the absolute value of the EM coefficient α_1 in Model 3 is significantly smaller than the coefficient β_1 in Model 1, which proves that DF plays a part in the mediating effect. It also means that the EM of energy companies has contributed to FS through DF. In general,

Table 9. The results of the mediating effect model.

	Model 1 (1st step)	Model 2 (2nd step)	Model 3 (3rd step)
Dependent variable	*FS*	*DF*	*FS*
EM	3.32***	1.21***	1.15**
	(4.41)	(2.49)	(3.31)
DF			3.25***
			(4.95)
AdjustedR^2	0.515	0.495	0.552
F-value	20.29***	16.14***	23.91***

***, ** denotes significance at 1%, 5% levels, respectively; () represents *Z*-value.

the mediating effect model verifies that EM promotes FS through DF, which reveals the "EM → DF → FS" transmission mechanism.

Retesting the interaction effect: Threshold effect model

The results of the "interaction term test" show that EM promotes FS through DF. However, another limitation of the "interaction term test" is to assume that "the impact of EM is a linear relationship of monotonous decreasing or increasing", while the existing studies show that the impact of EM on FS is a nonlinear relationship,[68,69] which may result in the following question: Is there a nonlinear relationship between EM, DF, and FS? In fact, this means that the impact of EM may have a threshold effect, that is, there are significant differences in the impact of DF on FS for different thresholds of EM. Therefore, this paper improves the "interaction term test" and employs the threshold effect model proposed by Hansen[70] to test the nonlinear relationship between EM, DF, and FS. In other words, test whether the impact of DF on FS has a threshold effect based on EM. Based on equation (2), we construct the following panel threshold model

$$FS_{it} = a_0 + a_1 DF_{it} I(Em_{it} \le \gamma_1) + a_2 DF_{it} I(\gamma_1 < Em_{it} \le \gamma_2) + \cdots + a_n DF_{it} I(\gamma_{n-1} < Em_{it} \le \gamma_n) + a_{n+1} DF_{it} (Em_{it} > \gamma_n) + \beta X_{it} + \varepsilon_{it} \tag{10}$$

where Em_{it} is the environmental management, namely, the threshold variable in this paper. γ is the unknown threshold value of EM. $a_1, a_2, \ldots, a_n$ and a_{n+1} are the coefficients of DF on FS when the threshold variable is in different ranges, respectively. If there is a significant difference between $a_1, a_2, \ldots, a_n$, and a_{n+1}, it means the specific threshold value is valid. I (J) is the indicator function. If the condition in parentheses is satisfied, then $I = 1$, and if not, $I = 0$. $\varepsilon_{it} \sim iidN(0, \sigma^2)$ is a random disturbance term. The rest of the symbols have the same meanings as those in equation (2).

Table 10 shows the panel threshold model parameter estimates using EM as a threshold. From the table, it can be seen that when EM is lower than 5.51, the coefficient of DF on FS is 2.19; when EM is higher than this value, the coefficient is 2.47; and when EM is higher than the second threshold value 5.88, the coefficient is 2.94. This means that the higher the degree of EM implemented by enterprises, the greater the promotion degree of FS by DF.

Table 10. The results of the threshold effect model.

Threshold variable: EM	Coef.	Z-value
$DF_{it}I(Em_{it} \leq 5.51)$	2.19***	6.21
$DF_{it}I(5.51 < Em_{it} \leq 5.88)$	2.47***	6.95
$DF_{it}I(Em_{it} > 5.88)$	2.94***	7.74
Adjusted R^2	0.583	
F-value	7.65**	

***, ** denotes significance at 1%, 5% levels, respectively.

Conclusions and policy implications

Conclusions

In the context of a flourishing energy industry in China, companies are facing financing difficulties and excessive consumption of environmental resources. This paper studies the impact of energy companies' investments in EM and DF on FS. The results show that EM and DF promote FS, while the overall effect of DF on FS is affected by EM; that is, EM significantly promotes the positive impacts of DF on FS. When using the panel IV method that considers the endogeneity problem and the two-step system GMM method, the estimates still support this conclusion. When further applying the mediating effect model test, it can be found that DF is an important path for EM to affect FS, which verifies the transmission mechanism of EM → DF → FS. In addition, the impact of DF on FS has a threshold effect based on EM. In other words, there are significant differences in the degree of impact of DF on FS in different thresholds of EM. The conclusions of this paper can enable energy company managers to realize that investments in EM will increase the company's operating costs, decrease the financing costs and increase the corporate value. In the long run, investments in EM are conducive to the FS of companies.

Policy implications

According to conclusion above, we put forward some suggestions for financial sustainability of Chinese energy companies as follows.

First, investors in energy companies follow minimal environmental, social and governance standards in their investment decisions.[71] Two strategies can be followed when energy companies adopt environmental, social, and governance criteria. The first strategy is to avoid overexposure of environmental hazards. The second strategy is not only to reduce carbon-intensive investments but also to finance the transition to a low-carbon economy. The latter is centered on long-run value creation. The impact of economic activities on the environment is typically occurred in the long run.

Second, energy companies should conduct DF through multiple channels to minimize their average costs when developing their own core businesses. With the favorable advantages of DF, the scale of the company can be expanded, and large-scale energy groups can be established via capital operations to revitalize stock assets and achieve low-cost expansion. At present, the main channels for the DF of China's energy companies are bank lending and commercial credit. Therefore, the managers of banks and the operators of companies must be aware of the benefits of appropriate liabilities for the FS, relax the

restrictions on the refinancing, and promote the DF. In addition, the profitability of energy companies also reflects the signal transmission function of investment institutions for their refinancing. For companies with strong profitability and low asset-to-liability ratios, banks and related parties will relax financing conditions. In contrast, for companies with weak profitability and poor business performance, banks and related parties will strengthen the tracking and management of their DF.

Third, the government should provide subsidies and incentives to help energy companies operate effectively as well as environmentally. The government must also revise the laws and regulations related to environmental protection to create a green atmosphere and encourage stakeholders to support EM behaviors. Green benchmarking for companies in the energy industry must be promoted to implement their environmental protection activities.

In addition, this paper uses a factor analysis to measure FS, and the future research could use another method to measure FS, such as the sustainable growth model proposed by Colley et al.[72]

Author's note

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